

Spatial imagery for management of Submerged Aquatic Vegetation (SAV) in the River Derwent estuary

Evaluation of spatially referenced imagery for environmental inventory, surveillance and monitoring of submerged aquatic vegetation (SAV, including seagrass)



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Cover photo: Swans feeding on seagrass, River Derwent estuary. Photo by Richard Mount, 2009.

Summary

- The project involved a series of low-cost **air and field campaigns** including via small waterborne craft (kayak) and light fixed-wing aircraft with an aerial photography port in the floor. Satellite imagery was also obtained as it became available at low or no cost. The following **information base** was produced:
 - **Low-cost though-water aerial imagery** captured from a light plane with small-format digital cameras, including infrared imagery. Imagery was captured for the upper Derwent estuary, Cornelian Bay, Ralphs Bay and Half Moon Bay.
 - For the upper Derwent estuary, the images were used to produce a very high resolution georeferenced **orthophoto mosaic** with an accuracy of ~1 m. The mosaic is the best image map available to date.
 - A **spatial database** that is designed to support monitoring purposes and that contains
 - SAV habitat mapping
 - Proposed mapping and names for the seagrass “banks”
 - A time series of georeferenced imagery over the upper Derwent estuary.
 - Spatially referenced **oblique imagery** from the air, the shores, the water surface and underwater – all publically available at <<http://picasaweb.google.com/dep2utas>>.
- **Descriptive and quantified information processing methods** were developed about the submerged aquatic vegetation of the upper Derwent estuary to assist management activities, as follows:
 - A proposed approach to **classification** of the imagery to extract ecologically meaningful information, with classes including seagrass condition, rhizome mats and bare mud.
 - A proposed method for interpreting the imagery using “**megaquadrats**”. Three such examples are provided from the existing spatial database in this report.
 - A proposed method for efficiently adding to the **monitoring time series**, both into the future and recovering past imagery.
- It is possible to **detect changes** in physical properties in the imagery that are indicative of key ecological processes in the upper Derwent estuary, including
 - Changes in the location and extent of actively growing seagrass via bright green foliage
 - Changes in the location and extent of benthic cover including bare mud, seagrass and rhizome mat
 - Changes in the location and extent of seagrass “pool” habitat (i.e. openings in the seagrass canopy a few meters to 10s of meters wide)
 - Changes in the location of tidal/drainage channels within the seagrass banks
- The imagery could **not** be used to identify the deep edge of the seagrass beds, seagrass density (percent cover) or patchiness. The data suitable for assessment of microphytobenthos or *Macrocystis* was also not obtained.
- It is **recommended** that
 - The vast archive of **historic aerial photography over the past 60 years** is assessed for to provide a context for monitoring into the future as it is almost certain that suitable imagery will be found.
 - **New aerial imagery** is collected mainly via light fixed-wing aircraft, though other sources should also be considered.
 - **Geo-located “water surface” imagery** is collected in key locations for monitoring purposes.
 - All imagery be stored in a **spatial database** capable of producing time series via megaquadrats

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1. Introduction

This project is designed to collect spatially referenced remote sensing imagery to identify practical and feasible methods of supporting the environmental surveillance, inventory and monitoring of submerged aquatic vegetation (SAV), in particular, targeting seagrass in the upper and mid Derwent estuary.

The imagery is intended to produce inventory and monitoring information products that are ecologically relevant to the management of the SAV in the Derwent estuary. Initial variables of interest were; changes in location of deep edges, seagrass density (percent cover) and patchiness (spatial metrics), though other variables are to be extracted where the imagery permits.

The following additional assessments will be undertaken, if resources allow:

- microphytobenthos (MPB) in the upper estuary
- MPB throughout sandflats within greater Ralphs Bay
- seagrass at South Arm (notably Halfmoon Bay), and
- *Macrocystis* (giant kelp) along the eastern Tinderbox Peninsula and Iron Pot areas.

This work was initiated and guided by the Derwent Estuary Program and undertaken by the School of Geography and Environmental Studies, University of Tasmania.

2. Methods

Broadly, the project involved a series of low cost air and field campaigns including via small waterborne craft (kayak) and small fixed wing aircraft with an aerial photography port in the floor. Satellite imagery was also obtained as it became available at low or no cost. All geoprocessing was done in ESRI ArcMAP™ Version 10, with data referenced to MGA94 Zone 55 (GDA94) and AHD vertical map datum. The production of orthophotos was conducted with Myriax Landscape Mapper Version 1.4 using the Climate Futures LiDAR data for relief correction.

Supporting data was supplied by the Tasmanian Aquaculture and Fisheries Institute (TAFI) in the form of contour maps, seagrass sample grabs and spatially located video imagery.

2.1. Study Area

The Derwent Estuary covers an area of nearly 200 km² extending from New Norfolk to a line between Tinderbox and Iron Pot (Derwent Estuary Program, 2009). This report focuses on the upper Derwent estuary; in particular, on the seagrass banks from the Jordan River to Murphys Flats (see Figure 2). The seagrass habitats are characterised as “banks” as they are almost uniformly shallow (i.e. approx. 1 m depth), are generally covered in seagrass and form the banks of the main river channel itself. The term “bank” is consistent with other large flat elevated areas in intertidal and shallow subtidal areas e.g. Corner Inlet, near Wilsons Promontory, Victoria. The names of the seagrass banks are proposed to assist with communicating about the habitats in the area i.e. Dromedary Bank, Granton Bank, Jordan Bank, the two smaller Bridgewater Banks (east and west) and the Murphys Flat Bank.

2.2. Image acquisition

Imagery was required to, firstly, establish what ecological and environmental properties can be detected, and, secondly, to conduct a trial in time series analysis to evaluate the properties that are tractable to change detection. Two aerial photographic missions were conducted as follows:

1. 2009 June 2nd, two sets of images were obtained:
 - a. Obliques images were captured in early winter in late afternoon with a relatively high tide using a digital SLR camera. Areas covered included Half Moon Bay, Ralphs Bay, Cornelian Bay and the upper Derwent sites including all the seagrass banks

shown in Figure 2. These photos were **geo-referenced** to the shores of the Derwent in the upper estuary and are used to visualise prominent features such as the bright green seagrasses on the Dromedary and Granton Banks.

- b. General oblique images useful for assisting interpretation of the main images.
 - c. Mission cost approx. \$1,000 (including planning) and image rectification cost approx. \$900
2. 2010 February 19th, four sets of images were obtained:
- a. Vertical high resolution digital SLR images. These images were used to generate an **orthophoto mosaic** ("photo map") in Landscape Mapper version 1.4 using the Climate Futures LiDAR digital elevation model (DEM) to assist with relief distortion. The positional accuracy achieved is high at ~1 m.
 - b. Vertical **infrared** and vertical **natural colour** imagery with high quality Canon G10 compact cameras. These images were used to produce an infrared image mosaic. The horizontal accuracy was less than the main orthophoto mosaic and is considered useful for assisting with image interpretation. The bright green and emergent vegetation shows up well in this sort of imagery.
 - c. General oblique images in infrared (see Figure 1) and natural colour useful for assisting interpretation of the main images.
 - d. Mission cost approx. \$1,200 (including planning) and image rectification cost approx. \$1,500

Other complementary imagery was collated and obtained at low or no cost (in chronological order):

- 3. 2010 January 30th: Rapid Eye satellite imagery purchased by the NRM Regions of Tasmania for environmental management purposes. The imagery has five bands including a "red edge" and near infrared band and a 5 meter ground pixel. This imagery was mostly used as backdrop imagery for the map making, but also makes a contribution to the time series analysis.
- 4. 2009 September 28th: a small screen grab of GeoEye satellite imagery over the Dromedary Bank was obtained from Google Earth and used to visualise the banks under flood conditions. The water is turbid with suspended sediments.
- 5. 2008 March 19th: Air photos from Google Earth extracted as screen shots and georeferenced in ArcGIS for visual comparison purposes. Much effort was made to find the owner of these images but all leads were exhausted. These images are the best though-water images for the middle and lower Derwent estuary as they were captured when the water was particularly clear. The series does not cover the Dromedary Bank.
- 6. 2003 October 13th: Quickbird satellite imagery from the widely available Greater Hobart mosaic was used as part of the time series work. Unfortunately, the imagery was captured at a time when the water was relatively dark and many underwater features are obscured, though substantial useful information was still captured.
- 7. 2001 January 3rd: TASMAP, ILS produced orthophotos licensed to the Derwent Estuary Program. These photos have little underwater detail and are mainly used to assist with locating the other imagery and the shoreline. A small amount of underwater information was extracted for the time series. Base image by TASMAP, © State of Tasmania



Figure 1 Oblique infrared image of the Dromedary Seagrass Bank and Dromedary Marshes looking up river to the west. Vegetation generally shows up brightly in infrared images.

2.3. Field data acquisition

Field trips to collect *in situ* observations and spatially located photos were conducted on the following dates:

Date	Transport	Personnel	Comment
2009-01-13	Car and foot	Jason Whitehead	Shore based observations of seagrass and epiphytes
2009-04-30	Car and wading	Richard Mount and Mark Morffew	Shore based observations of seagrass and epiphytes
2010-02-13	Kayak (sounder, GPS and underwater camera)	Richard and Marylyn Mount	Mainly the Dromedary Bank to capture observations close to anticipated Flight 2
2010-02-28	Kayak (sounder, GPS and underwater camera)	Richard and Marylyn Mount	Mainly the Granton Bank (west) to capture observations closely following Flight 2
2010-03-13	Kayak (sounder, GPS and underwater camera)	Richard Mount and Gerald Harwood	All banks to capture observations closely following Flight 2
2010-12-31	Kayak (sounder, GPS and underwater camera)	Richard and Marylyn Mount	Capturing observations of the Granton Bank (east)

Most of the spatially located imagery is available at <<http://picasaweb.google.com/dep2utas>>

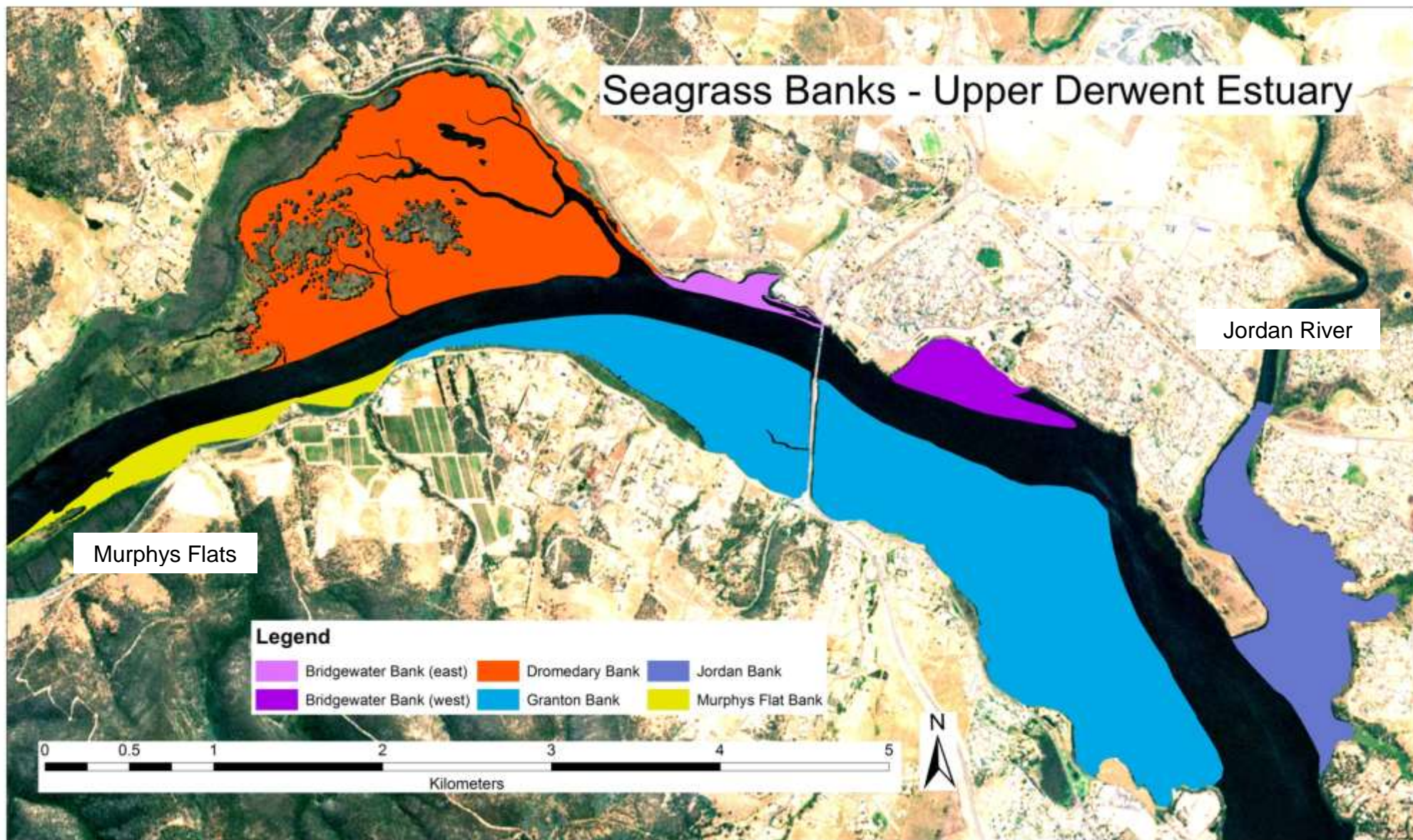


Figure 2 The seagrass banks of the upper Derwent estuary. The names are proposed to assist with communicating about the habitats in the area.

2.4. Mapping Classification Scheme

All mapping work requires a classification scheme that defines classes that are “fit-for-purpose”. In this case, the key ecological features of interest are the submerged aquatic vegetation of the Derwent estuary, with a particular focus on the seagrasses. The classification scheme presented below is based on close analysis of the spatial imagery collected as well as field observations including visual inspections, underwater photographs, underwater videography (Lawler, 2009) and seagrass sample grabs (Lawler, 2009). It also draws on the following key reports, Roberts et al., 2001 and Lucieer et al., 2007.

Species

The species of seagrass present in the study area are only partially known and there is some apparent disagreement between reported listings. The following reliable identification is from Roberts et al., (2001),

“Samples from a selection of sites used for autotrophic production (A1, A3, B3, C3 and D1) were collected in November and examined at the Tasmanian Herbarium, University of Tasmania by Dennis Morris. All the samples with *Lepilaena* present (B3, C3 and D1) were of one species, *Lepilaena cylindrocarpa*. *Ruppia* was present at all sites sampled. However due to a lack of flowers, a positive identification could only be made at site D1 of *Ruppia megacarpa*. The unidentified *Ruppia* sp. in the other samples was most probably *Ruppia polycarpa* based on the leaf morphology and distribution, but may alternatively be *Ruppia maritima* (Dennis Morris, Tasmanian Herbarium, Uni. of Tasmania, pers.com.).” The sites listed are in the upper Derwent estuary within the study area apart from A1 and A3 as per Figure 3.

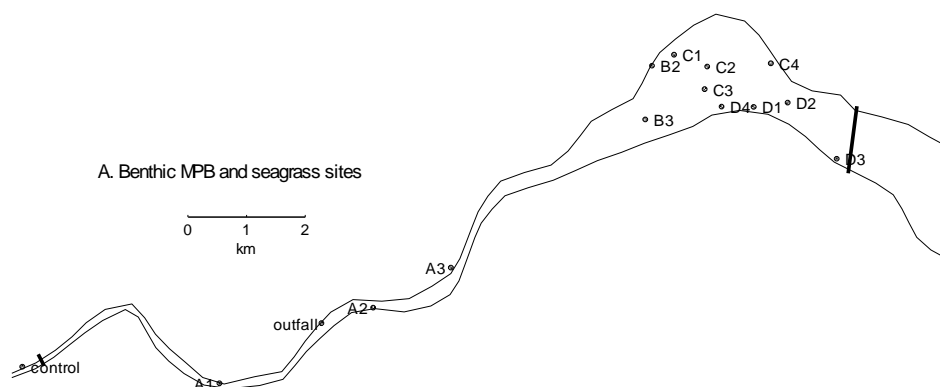


Figure 3 Seagrass sample site in Roberts et al. 2001.

The same report lists a *Zostera* species (i.e. an “eelgrass”) as being the other main seagrass present, however other authors consider that the other main species present is a *Heterozostera* species. Lawler (2009) discusses this issue and notes that it is difficult to distinguish between *Zostera* and *Heterozostera* species in the field as they resemble each other closely. Further, there have been recent changes in the taxonomy of *Heterozostera* (Kuo, 2005) and Lawler (2009) considers that there may be two species present, *H. tasmanica* and *H. nigricaulis*. In general the seagrasses will be referred to in this report by their genera names, i.e. *Ruppia*, *Lepilaena* and *Heterozostera*.

Classification Scheme

The mapping methods used for this study are unable to definitely distinguish separate seagrass species and an alternative set of classes is required. Based on close observations of the available data and habitats in the field the following classes are proposed:

Table 1 Classification Scheme class descriptions

Class	Comment
Bright submerged aquatic vegetation (BSAV)	Areas of very bright, light green foliage of either <i>Lepilaena cylindrocarpa</i> or, most likely, <i>Ruppia spp.</i> These appear to be actively growing, fresh leaves and are typically close to the water surface (see Figure 4).
Dark submerged aquatic vegetation (DSAV)	Areas of dark green foliage. Species could include <i>Lepilaena cylindrocarpa</i> , <i>Ruppia spp.</i> or <i>Heterozostera spp.</i> , though generally these areas are dominated by <i>Ruppia spp.</i> This foliage may be close to the surface or occur at depths down to, typically, 1-2 m.
Rhizome mat	Areas generally devoid of a seagrass canopy, but with the muddy substrate filled with rhizomes and stems. (Note: This class is not always easy to distinguish from bare mud or from DSAV) (see Figure 5)
Bare mud	Areas of “bare mud”, that is without seagrass and or dense rhizomes
Channel	The main river channel is distinguished by its size, steeply sloping banks and depth. The smaller channels draining the seagrass banks.
Marsh	Areas of marsh including saltmarsh, tidally influenced marsh and freshwater marsh. See Prahalad et al (2010) for details of the species.
Scrub	Areas of woody shrubs, generally occurring inland of the marshes. See Prahalad et al (2010) for details of the species.



Figure 4 Bright submerged aquatic vegetation (Granton Bank)



Figure 5 Typical rhizome mat, note the roots and rhizomes (Dromedary Bank).

2.5. Data Model and metadata

This data model and dictionary details the attribute fields used in the Upper Derwent Estuary Submerged Aquatic Vegetation (SAV) Habitat Map.

The somewhat cryptic field names used for each attribute field are designed to be compatible with some formats which allow only limited field name lengths. Each geomorphic attribute is recorded within the attribute table in two formats, as both a numerical (character string) code, and as an equivalent verbal descriptor. This allows greater flexibility in using the map and analysing map data.

Dataset name: Upper Derwent Estuary Submerged Aquatic Vegetation (SAV) Habitat Map 2010, version 1

File name: derwent_upper_est_habmap_2010_02_19

Co-ordinate System: Australia Map Grid Zone 55 GDA 1994

GIS data type: Vector polygon map, as ESRI shapefiles

Description: Polygon vector map

Data Dictionary: (see Table 2)

2.6. Aerial imagery time series method

For this study, the purpose is to identify feasible and practical information products based on remote sensing that can support environmental surveillance, inventory and monitoring of submerged aquatic vegetation (SAV). To this end, the aerial imagery time series methodology is based on that described in Mount (2007). This method has been applied in Vitoria by Ballet al. (2006) and Ball and Blake (2007). It was recently applied in Mount and Otera (2011) for Kingborough Council in North West Bay (Mount and Otera, 2011). Essentially the method entails identifying specific areas, or “megaquadrats”, and using them to compare spatially located imagery through time. The use of a fixed spatial reference area (i.e. the megaquadrat) enables improved visual comparisons of time series imagery and, if required, can support quantitative analysis as well.

For this exploratory study, a visual comparison was conducted. The megaquadrats were positioned where a mix of habitat types are present with some evidence of change visible. The size of the megaquadrats should be varied depending on their application. For this study, three megaquadrats are used and they range between 24 and 90 Ha each (i.e. sides of 400 m to 1,200 m). In the future, other megaquadrats can be selected and time series analysis conducted relatively quickly now the spatial database is in place.

The imagery that can be used with the method can be any imagery taken from above including via:

1. Satellite imagery
2. Aerial photography of all sorts and scales
3. Kite or balloon photography
4. Remote controlled autonomous aircraft (e.g. Oktocopter)
5. Pole photography (e.g. 6 m carbon fibre pole)

Image types can be grayscale, colour, multispectral (including near infrared) or hyperspectral. For this study a range of image types were acquired (see Section 2.2) with a relatively limited date range of 2001 to 2010. Each image within the megaquadrat can be visually inspected for the variables of interest and compared to the other times. More detailed work could be done by mapping or conducting image analysis on each image in the time series and extracting quantified variable for comparison.

Table 2 Data dictionary for the Upper Derwent Estuary SAV map

Field	Type	Width	Attributes	Comments
Habmapdesc1	string (text)	40	dark submerged aquatic vegetation; bright sav rhizome mat; bare mud; marsh; scrub; channel; land; bridge; unknown.	Descriptions of the land cover and habitat types
HabmapCode 1	string (text)	10	DSAV;BSAV;RZMT; BMUD;MRSH;SCRB;LAND;BRDG;CH NL;UNKN.	Codes for the land cover and habitat types in the same order as the descriptions
Habmapdesc2	string (text)	40	vegetated (submerged); unvegetated (submerged); vegetated (onshore); channel; land; unknown.	Simplified descriptions of the land cover and habitat types
HabmapCode 2	string (text)	10	SAV; UVEG; VEG; CHNL; LAND; UNKN.	Codes for the land cover and habitat types in the same order as the descriptions
SMSub1Desc	string (text)	20	Reef; Cobble; Sand; Silt; Seagrass; Aquatic Macrophytes; Vegetated	Descriptions of the land cover and habitat types
SMSub1Code	string (text)	10	RF; CB; SA; SI; SG; AQ; VEG	Codes for the land cover and habitat types in the same order as the descriptions
SMSub2Desc	string (text)	20	Reef; Unvegetated; Seagrass; Aquatic Macrophytes; Vegetated	Simplified descriptions of the land cover and habitat types
SMSub2Code	string (text)	20	RF; UNVEG; SG; AQ; VEG	Codes for the land cover and habitat types in the same order as the simplified descriptions
Metadata:				
Created	Date	-	Date of data currency or last update, appearing as "DD/MM/YYYY"	Refers to the date the polygon was drawn
Authors	string (text)	75	Name of the authors	Refers to the polygon authors
ImageSourc	string (text)	250	Provides a range of information including name of the person who captured the mage image capture, when and with which camera or sensor. Also information about the orthorectification method and accuracy. For example, "Richard Mount and Stewart Wells / Feb 19, 2010 / Canon Eos 5D / 5500 feet / Orthorectified with LiDAR, RMS less than 1 metre"	Refers to the image authors and other characteristics
FieldTrip	string (text)	20	Indicates the date of the field trip to acquire the imagery, appearing as "DD/MM/YYYY"	Indicates the date of the field trip to acquire the imagery

Typically variables that could be extracted include:

1. Changes in location and extent of target habitats
2. Changes in habitat types or properties such as species, structure, vegetation density (percent cover), epiphytic loading or the deep edge of seagrass beds
3. Geomorphological changes such as changes in channel positions

2.7. Water surface imagery time series method

Photo transects captured by a camera at or immediately below the water surface is a low-cost method that could be used to monitor submerged aquatic vegetation in some selected locations by building a time series photo library that can be queried spatially. The method can be applied in a number of ways depending on the purpose and the environmental conditions at the target site.

Purposes could include:

1. Inventory
 - a. seagrass species
2. Surveillance
 - a. invasive species
3. Monitoring
 - a. seagrass density (percent cover)
 - b. epiphytic growth

Useful approaches could include wading or using shallow water craft e.g. kayak. There are many waterproof cameras now available that would be suitable. A GPS should be used to position the imagery – simple methods now exist (e.g. EasyGPS software) for geo-locating imagery. All spatially located imagery can be easily shared on the web via sites such as Picasa Web albums or Flickr. These sites allow users to view the imagery for specific locations via a map interface. For example, the imagery collected for this study is available at <<http://picasaweb.google.com/dep2utas>>.

The water surface imagery time series methodology is in a nascent state of development, though could be easily operationalised. The **wading** approach taken here was to trial wading into the sea at selected sites and taking downward pointing photos with a digital SLR from chest height. It is important to reduce surface glare and to maximise through-water penetration.

Water surface image capture wading procedure

A draft ideal procedure could be as follows:

1. Identify selected sites. Choices need to be made about
 - a. The purpose of the photo monitoring
 - b. Fixed or random positioning of transects
 - c. Safety considerations e.g. firm sediments only for wading; wader safety training.
2. Equipment needed:
 - a. Camera (ideally waterproof so underwater shots can be obtained)
 - b. GPS (ideally a differential GPS, but that is not necessary); one that can have its tracklog and waypoints downloaded to a computer.
 - c. Depending on the water temperature, waders and/or warm clothes
3. Prepare the camera and GPS
 - a. Use a polarising filter if available
 - b. Set the camera time to GPS time (if using a GPS)
 - c. Check the coordinate system in the GPS is suitable (probably MGA GDA94 or similar; WGS84 is probably OK too)
 - d. Ensure the camera and GPS stay close together (within a metre or so) throughout the shoot.

4. Image capture

- a. Sunny, still conditions are best and a low tide helps too.
- b. Take some locating shots of the surroundings
- c. Take a photo of the GPS (helps with synching the time later on)
- d. Start taking photos of the sea floor, minimising glare and checking that the photos are coming out well. You may have to adjust the exposure values (e.g. open up the shutter or slow the shutter speed as the bottom may be relatively dark). Take some photos from below the water surface if your camera is suitable. It is fine to include your feet in the image as this can provide a size reference.
- e. Depending on the sampling strategy, walk slowly into deeper water and take photos as you go – perhaps every 5-10 metres.
- f. When you are as deep as you can go, turn around and take some more locating shots, then keep taking more sea floor photos on the way back in.

5. Image processing

- a. Download the images and the GPS tracklog to a computer
- b. Write the locational information into the image header file somehow (e.g. using EasyGPS)
- c. You may choose to increase the contrast or otherwise process the images, but don't do too much to the originals.
- d. Upload the images to, an internet photo library archive e.g.
<<http://picasaweb.google.com/dep2utas>>

A series of 4 **kayak** trips were made to collect data. The kayak was fitted with a Garmin GPSMap 176 GPS and sounder and recorded depth, temperature and position. A Canon G10 camera in an underwater housing was used to capture images both above and below the water surface and geo-located using the GPS tracklog. The procedure is much as for the wading procedure listed above apart from issues relating to management of the boat including boat safety.



Figure 6 Kayak fitted with GPS and sounder

3. Results

3.1. Mapping current habitat extent

The mapping effort in the upper Derwent estuary has produced a detailed habitat map in GIS format (see Figure 8). These maps are considerably more detailed over the shallow banks than the habitat mapping conducted, for example, by TAFI in the 2007 resurvey (Figure 9). This is because the TAFI method generally requires a boat with a sounder to pass over the habitat and this is not possible in water depths of a metre or less. The image based mapping used here is complementary to the TAFI approach as it can distinguish bottom features in the shallow waters though is limited by water clarity.

The areas of the **seagrass banks** are presented in Table 3 in size order and the Granton Bank is clearly the largest, though it is divided by the Bridgewater Bridge causeway. The shape of the channels draining the western end of the Granton Bank is driven by the causeway as the channels run down to the causeway and then turn a right angle and run alongside the causeway. Most other channels have a more natural form. Most of the banks exhibit a common morphological pattern of being deeper at their downstream end and often have a channel entering the bank from this end.

The Dromedary Bank shares a river bank platform with the Dromedary Marshes and there appears to be active colonisation of the seagrass bank by the saltmarsh species in the area including the *Juncus kraussii* (Figure 7). For more detail on these marshes see Prahalad et al. (2009) and MacDonald (1995).

Table 3 Areas of the seagrass banks

Bank Name	Area (m ²)	Area (Ha)
Granton Bank	3,142,647	314.2
Dromedary Bank	1,926,148	192.6
Jordan Bank	867,059	86.7
Murphys Flat Bank	256,316	25.6
Bridgewater Bank (west)	240,211	24.0
Bridgewater Bank (east)	88,368	8.8



Figure 7 *Juncus kraussii* on the Dromedary Bank

The **current extent of habitats** was mapped based on the January 2010 image mosaic and supplemented with the infrared imagery and field observations, especially the spatially located still underwater photos and the spatially located video provided by TAFI (Lawler, 2009). The boundary between some classes is not as “crisp” as that defined by the mapping polygons and subjective judgement needed to be used when placing the boundaries. For example, the boundary between the “rhizome mat” class and “dark SAV” is not always clear. Further field work would assist with clarifying the boundaries. Areas are reported in Table 4.

Table 4 Areas of the habitat types. Note that the areas calculated for the channel, marsh and scrub classes are for the areas mapped only and are all truncated at the imagery boundary.

Habitat Name	Area (m²)	Area (Ha)
bright submerged aquatic vegetation (BSAV)	2,262,065	226.2
dark submerged aquatic vegetation (DSAV)	3,028,797	302.9
rhizome mat	1,252,057	125.2
bare mud	61,633	6.2
channel	4,260,724	426.1
marsh	1,338,497	133.8
scrub	2,145,395	214.5
unknown	156,450	15.6

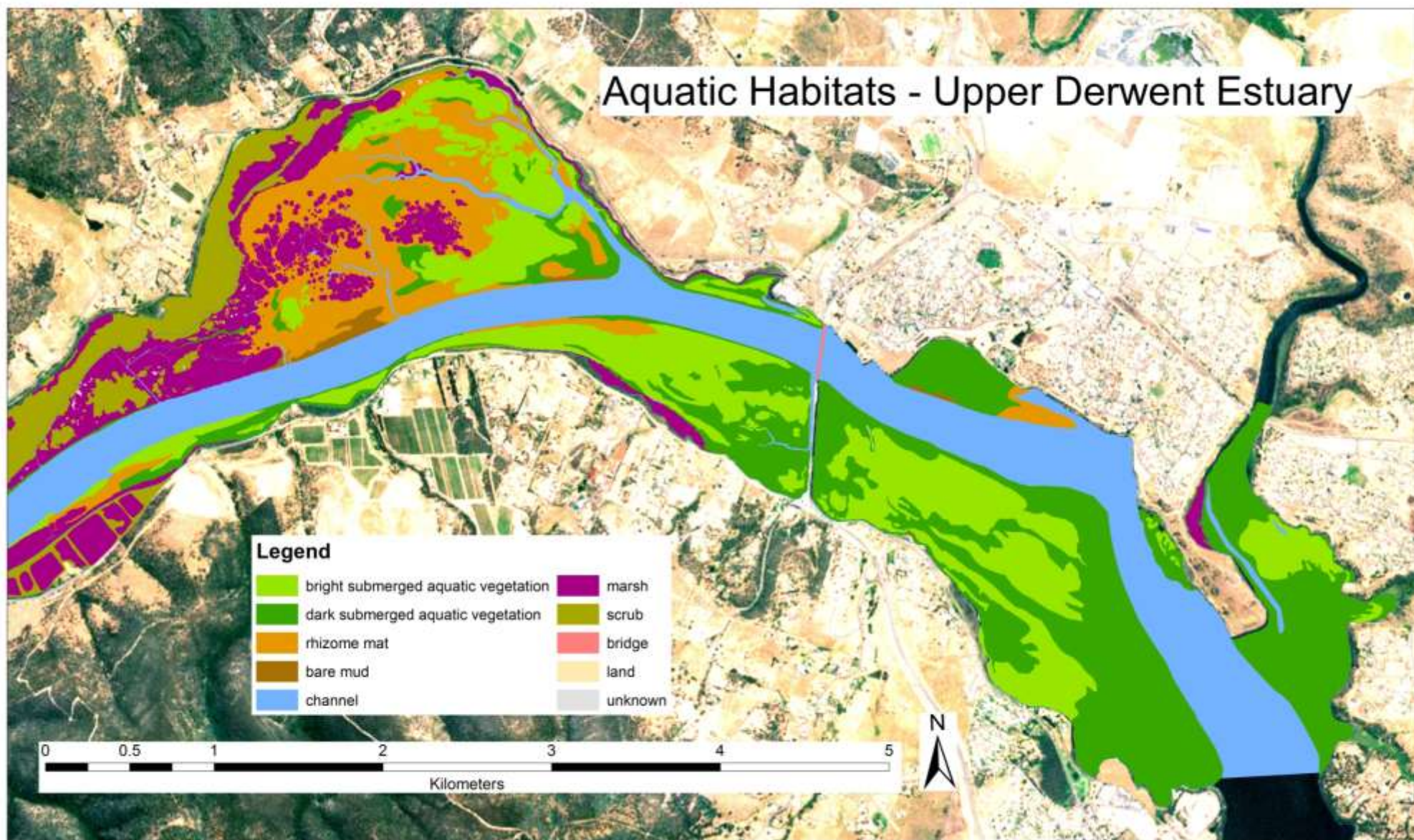


Figure 8 Submerged aquatic vegetation mapping in the upper Derwent estuary 2010. The SAV is dominated by *Ruppia spp* with a band of *Heterozostera spp* along the main river channel in the west.

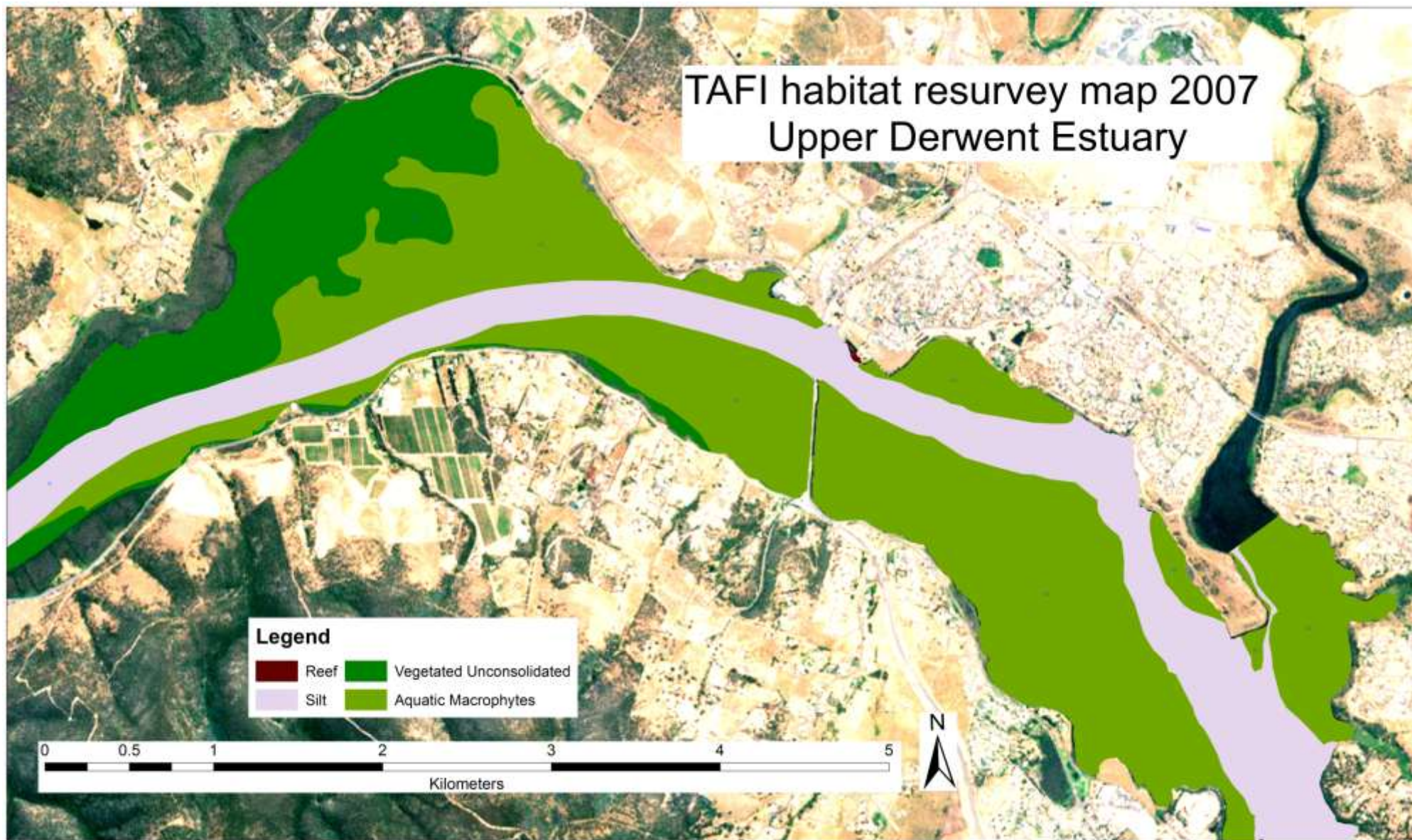


Figure 9 Habitat mapping completed by TAFI in the 2007 resurvey of the Derwent estuary habitats

3.2. Primary productivity

Based on published biomass figures for *Ruppia megacarpa* (Brock, 1983) and for a combination of *Ruppia megacarpa*, *Heterozostera tasmanica* and *Zostera muelleri* (Ierodiaconou and Laurenson, 2002) that range from ~100 to 380 gm m⁻², the total standing biomass (“standing crop”) of the seagrass component of the combined SAV classes is in the order of between 500 and 2,000 tonnes. Given the generally low epiphyte levels found throughout the banks in the upper Derwent estuary (e.g. Roberts et al. 2001; Lawler, 2009; field observations), the total standing crop estimate for the seagrass and epiphyte combined is probably encompassed within the estimated range for seagrass (i.e. between 500 and 2,000 tonnes).

Based on the primary productivity rates calculated by Roberts et al. (2001) the production of carbon for the mapped banks is in the order of 26 tonnes per day in May and about 80 tonnes per day in November. Roberts et al. (2001) presented evidence that the seagrasses are the dominant primary producers in the study area by three or four times (see table below from Roberts et al. 2001). The high numbers of birds using the area for feeding and breeding corroborates this high level productivity (Figure 10). Up to 2,000 swans have been observed in the study area (pers. Comm. Stewart Blackhall, DPIPWE).

Table 5 Comparison of gross primary productivity of the major groups examined. Data are the mean productivity values for each sampling trip expressed as mg C. m⁻². h⁻¹ assuming a PQ and RQ of 1. Phytoplankton and bacterial production are based on a depth of 2 m for surface water. (From Roberts et al., 2001)

Primary Producer	February	May	July	November
Phytoplankton	2	5	--	--
MPB (microphytobenthos)	--	65	103	158
Seagrass	--	205	312	636
Bacterial secondary productivity	--	14 (mean for May/July)		



Figure 10 High numbers of animals graze on the seagrass itself (e.g. swans, ducks and yellow-eyed mullet) or on the animals and plants that live on or among the seagrasses (e.g. black bream, brown trout and short-finned eels).

3.4. Aerial imagery time series analysis

The megaquadrat approach has been established in the project's spatial database and was used to produce three time series using the available imagery including the imagery captured for the project and a variety of other imagery including satellite, Google Earth and orthophotos. This approach enables a comparison of the performance of the various image types. The results for the three selected megaquadrats are presented in Figure 11, Figure 12 and Figure 13. Each time series uses different images either because their coverage did not coincide with the megaquadrat or it was not of suitable quality. It is important to note that the time series is relatively short and there are three sources of 2010 summer images captured within 3 weeks of each other.

Megaquadrat 1 time series (Figure 11) shows some gains and losses of bright green SAV (BSAV) through time. In particular, a gain from the 2003 spring Quickbird image to the 2008 summer airphoto, though note the poor quality of the Quickbird image. The difference could also be partly explained by the seasonal growth habit of *Ruppia*. In the 2009 winter and 2010 summer images there is a fairly stable extent of BSAV, perhaps with a slight thickening of the BSAV in the summer images, though note that the water in the 2009 winter image was dark and the tide was high. The 2010 summer RapidEye image shows some image "salt and pepper" effects that are artefacts in the available image and do not reflect the usual quality of the RapidEye images. There is a clear change in the SAV patch in the lower part of the megaquadrat with a change in the periphery of the SAV patch from BSAV to dark SAV (DSAV). This is likely to be a natural transition from fresh new foliage to older and, possibly, senescing foliage. This is a change that is apparent in all the megaquadrat time series.

Megaquadrat 2 time series (Figure 12) indicates that there is little detectable change in BSAV extent from 2009 to 2010 other than a small increase in BSAV along the shores of the southern patch. Note that the river is in flood in the 2009 spring GeoEye image and that the water is bright and the seagrass banks are dark. Also note the foam streaks on the 2009 winter image caused by the katabatic winds. The 2003 spring Quickbird image is virtually useless, though the tidal and main channels are visible. The 2001 summer orthophoto similarly does not provide much useful information and it is not clear whether the pale patches are SAV or a muddy bottom.

Megaquadrat 3 time series (Figure 13) on the eastern side of the bridge shows large changes in the extent of BSAV. The three times that are included in change analysis are the 2003 spring Quickbird image, the 2008 summer AP and the 2010 summer images (i.e. natural colour and confirmation with the infrared). The 2010 summer Rapid Eye image was not used as it was both close in time to the 2010 summer image and also was less clear than the two airphotos on either side of it. The 2001 summer orthophoto is of poor quality and is only shown to illustrate the different image qualities. The changes are most obvious in the mid-right of the image where BSAV is firstly present in 2003, then changes to DSAV in 2008 and then back again to BSAV in 2009. Along the bridge on the left side of the megaquadrat, the BSAV apparent in the 2003 spring image is still there in 2008 summer but has darkened in the 2010 summer image.

In summary, areas of gain and loss are apparent in the megaquadrats, though the time series is limited and the image quality is mixed.

3.5. Water surface imagery time series analysis

Imagery captured at or under the water surface can be used to monitor benthic habitats in the study area. Simple trials were conducted by both wading and by using shallow water craft (i.e. kayak). Both methods proved viable for the given environment, wading where the sediments are firm enough to support the weight of the observer, and kayaking where the water is deep enough to float the boat. The resulting imagery is available for viewing at <<http://picasaweb.google.com/dep2utas>>.

Megaquadrat visual comparison - Granton Bank (west of bridge)

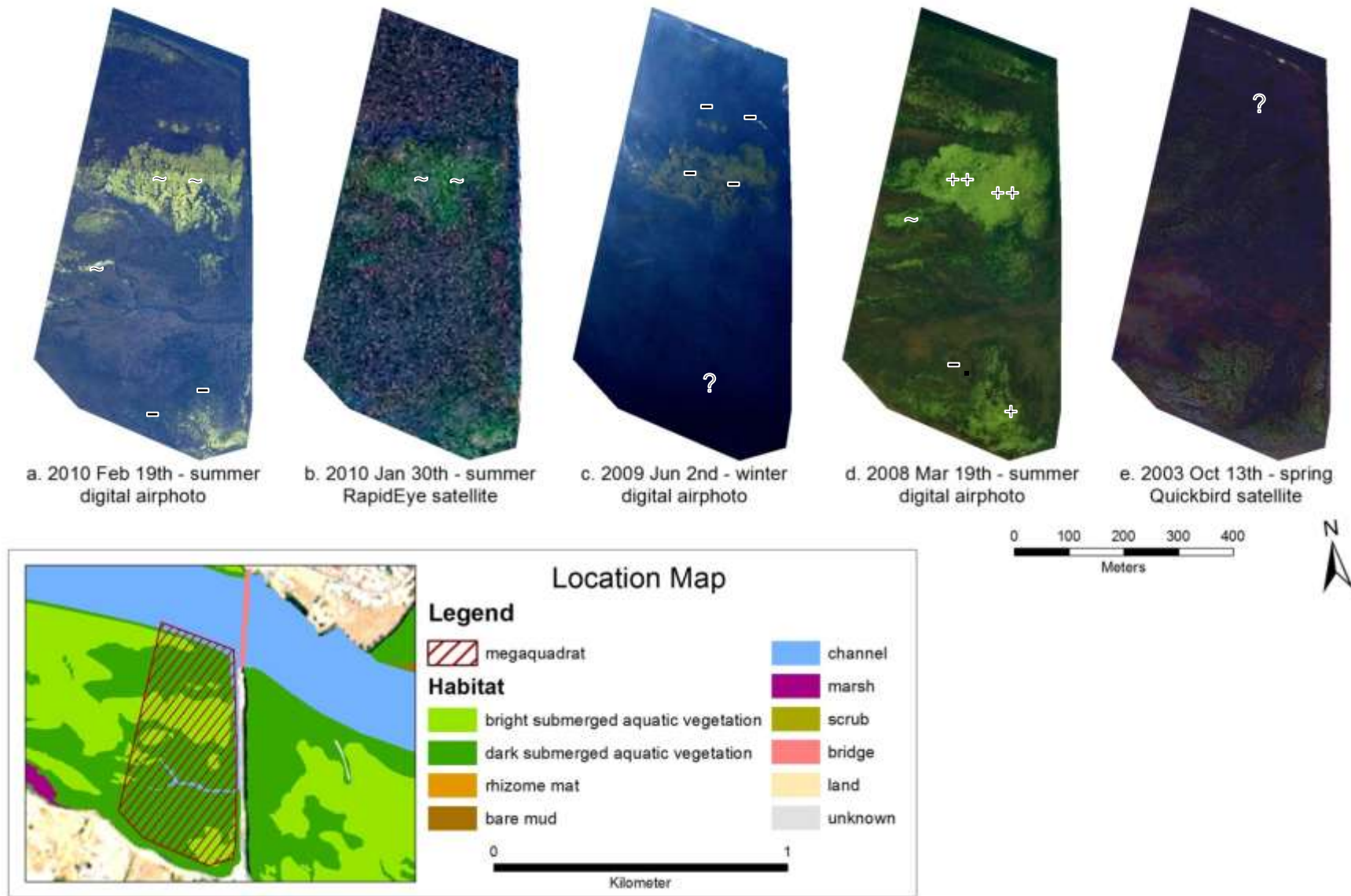


Figure 11 Aerial imagery time series: Megaquadrat 1, immediately west of the Bridgewater Bridge on the Granton Bank. Starting at the oldest image, changes are represented by “++” = big increase in BSAV; “+” = moderate increase in BSAV; “~” = no obvious change in BSAV; “-” = loss of BSAV; “?” = uncertain.

Megaquadrat visual comparison - eastern Dromedary Bank

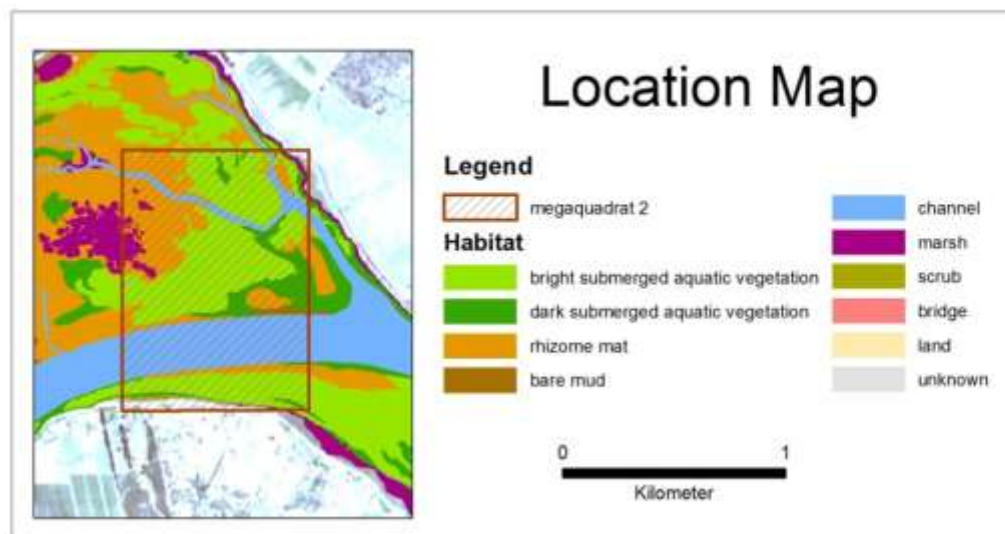
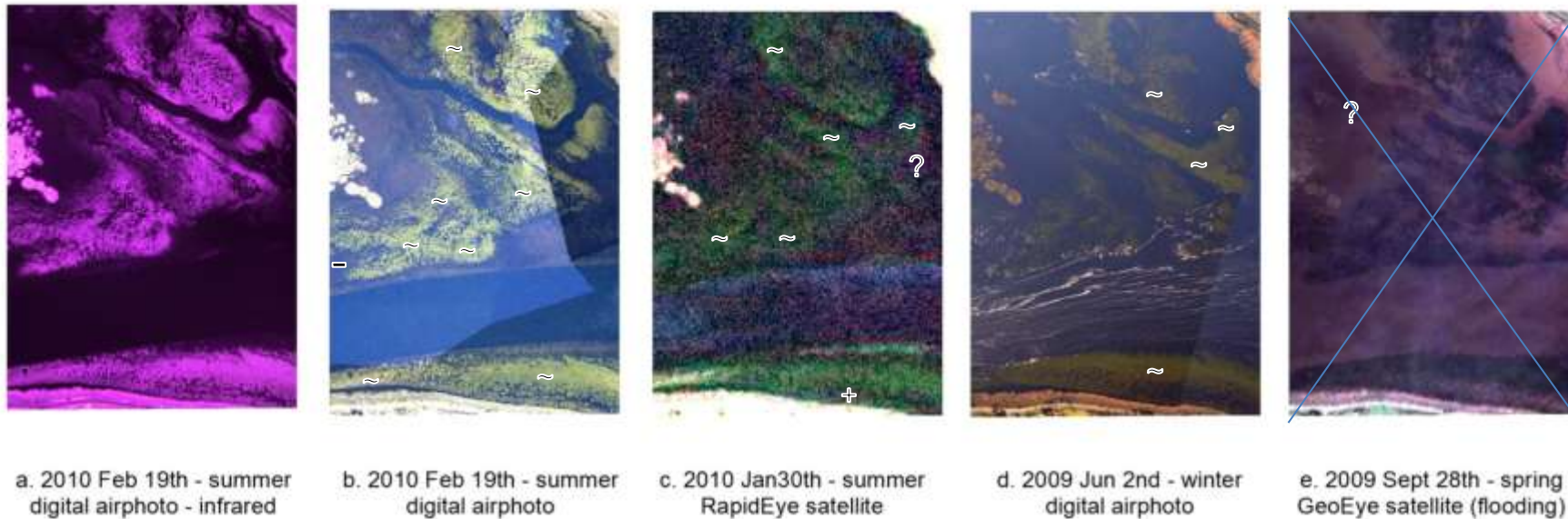
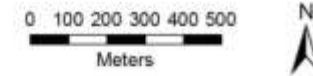
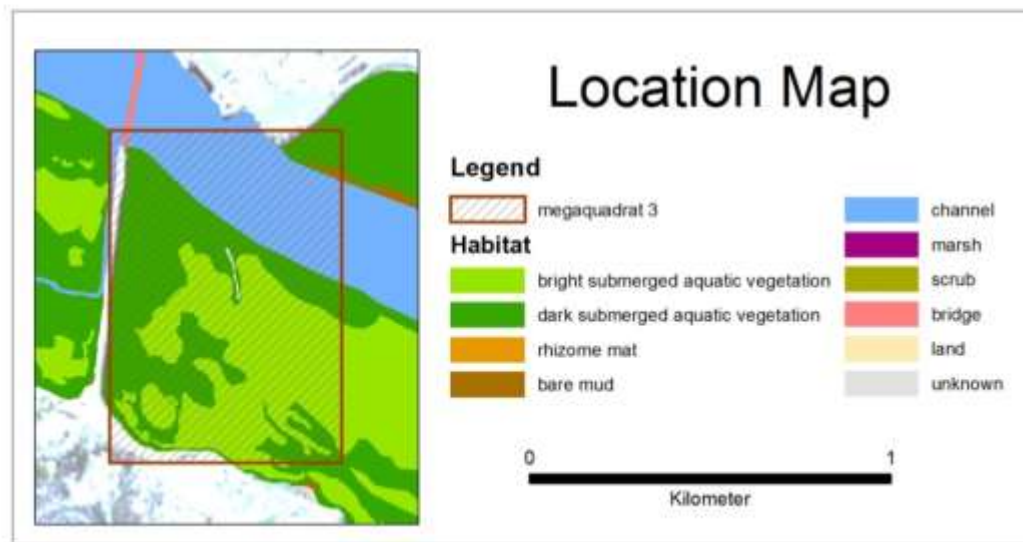
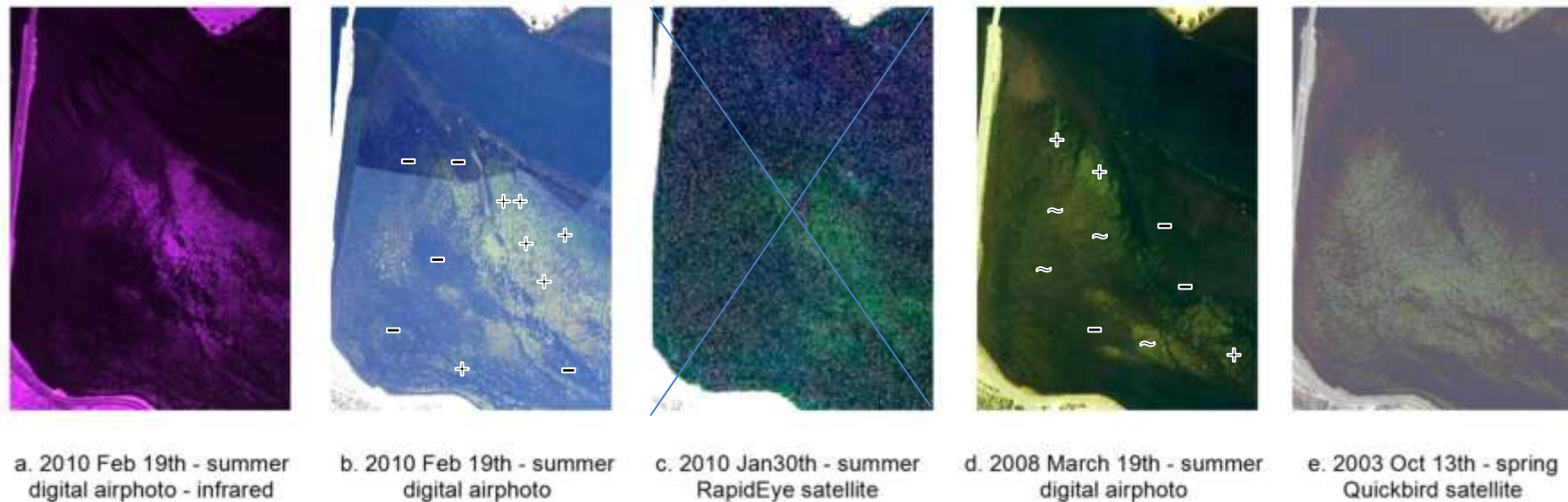


Figure 12 Aerial imagery time series: Megaquadrat 2, eastern end of the Dromedary Bank. Note the 2009 GeoEye satellite image was captured during a flood. Starting at the oldest image, changes are represented by “++” = big increase in BSAV; “+” = moderate increase in BSAV; “~” = no obvious change in BSAV; “-” = loss of BSAV; “?” = uncertain.

Megaquadrat visual comparison - Granton Bank (east of bridge)



0 100 200 300 400
Meters



Figure 13 Aerial imagery time series: Megaquadrat 3, immediately east of the Bridgewater Bridge on the Granton Bank. Starting at the oldest image, changes are represented by “++” = big increase in BSAV; “+” = moderate increase in BSAV; “~” = no obvious change in BSAV; “-” = loss of BSAV; “?” = uncertain.

4. Discussion

Bright green SAV monitoring

The reported areas in Table 5 show that the shallow seagrass banks are dominated by seagrass, primarily *Ruppia spp.* The bright green SAV has been mapped separately as it is, generally, clearly distinguishable from the other classes and it may be an indicator of key ecological processes, though this needs to be confirmed by a wetland ecologist or similar. It is possible to monitor the amount of fresh bright green growth in the area and gain some insight into the environmental conditions over the seagrass beds. For example, Roberts et al. (2001) provide evidence that the seagrasses are nutrient limited, and changes in nutrient levels may be reflected in seagrass growth rates. Direct browsing by swans is another significant influence on the structure of the seagrass canopy, though it is notable that the swans appear not to occupy the densest bright green patches (e.g. see Figure 10).

Light availability

Given that the seagrasses are generally occupying very shallow water and are often emergent, it may be reasonable to assume they have good access to light as there is very little water column over them. This may be the case even if water clarity is low due to CDOM or suspended particle. Roberts et al. (2001) also noted that the seagrass species here are well adapted to both low light conditions (e.g. winter) and high light conditions (e.g. summer). It may be that much of the seagrass on the banks of the upper Derwent is not particularly light limited. Another established mechanism for limiting light availability for seagrass is that of shading by epiphytic algae, where thick mats of filamentous algae grow over the seagrass, eventually killing it. Given the low levels of epiphytes observed over the seagrass banks (e.g. Lawler, 2009), this mechanism appears not be a major concern at the time of mapping.

Seagrass “pools” habitat

A habitat type that was not mapped, but could be extracted from the imagery if it was useful to do so is that of the seagrass “pool” habitat. This is where there are openings in very dense seagrass canopies measuring between about 2-20 metres across (Figure 14). The pool depth is typically down to the substrate and during the field trip on the 13th March 2010 the pools were frequently observed to have hundreds of fish in each one (Figure 15).



Figure 14 Example of seagrass “pool” habitat on the Granton Bank (east) indicated by the orange circle. The image is about 700 m across and the orange circle is about 170 m across.



Figure 15 Example of small fish found in the seagrass pool habitat.

Changes in benthic cover extent for biomass estimation

The benthic cover of the seagrass banks can clearly be monitored if the quality of the imagery is adequate. The area estimates enable the calculation of biomass (i.e. “standing crop”) if biomass estimates can be related to the mapped habitat classes. Ierodiaconou and Laurenson (2002) calculated the standing crop of the seagrasses in the Hopkins Estuary, Victoria by using ground survey methods to do the mapping and harvesting seagrass in quadrats to estimate the biomass. The entire area of the seagrass in the estuary was 40 Ha and the entire estuary is 160 Ha. The upper Derwent estuary seagrass banks are more than an order of magnitude larger and require a more efficient method of mapping for habitat change and biomass estimation purposes. This trial indicates that low-cost image capture is capable of supporting such estimates.

Changes in tidal channel morphology

The tidal channels are an important component of the seagrass banks as they enable the flow and circulation of water and provide access to the middle of the banks for marine organisms. They are often deep and well defined (e.g. Dromedary Bank). The position and shape of these channels could be monitored with high resolution through-water imagery.

Limitations of the approach

It is important to be realistic about the limitations of any sampling approach. The following is a discussion of what didn’t work and what to avoid in the future.

The number of flying days was limited by the weather, particularly during the winter and spring of 2009 due to extremely high rainfall levels making the water particularly turbid. Further complications were provided by the very strong katabatic winds (i.e. cold air drainage @ ~20 knots) present in the mornings in winter and spring and also the sea breeze, which penetrated right up to Bridgewater by about 4:00pm in the afternoon in summer. Though these were a problem, on close inspection of the winter 2009 imagery, the bright green SAV is still visible due to its close proximity to the surface and also to the excellent capacity of the SAV to damp the effect of any waves in the water surface (Figure 16) and also trap most of the foam streaks generated by the waves (Figure 17).

The imagery could not be used to determine the following:

- The deep edge of the seagrass beds, mostly due to the steep channel banks and low-contrast bottom types at the maximum depths of seagrass growth.

- Seagrass density (percent cover), mostly due to the growth habits of the species present (i.e. generally only grows in high densities with long leaf lengths), the dark water and the low contrast between the seagrass and the bottom.
- Patchiness (spatial metrics), due to the largely contiguous and consolidated form of the seagrass beds. The simplest forms of spatial metrics (i.e. changes in area) are all that is needed here



Figure 16 The SAV provides excellent damping of the wind waves, even in strong wind.



Figure 17 The katabatic winds (caused by cold air drainage) generate waves and foam streaks. The latter are visible in this image. Note that the foam streaks generally do not enter the areas of bright SAV.

5. Conclusions and Future Work

New through-water imagery was collected with low-cost digital cameras and using light fixed-wing aircraft, and then processed with high-precision LiDAR data to produce very accurate high-resolution photo maps (orthophotos) that clearly show subsurface features of ecological significance. There needs to be some field observations collected to ensure the quality of the image interpretation, but this can be effectively carried out using light, low-cost methods such as spatially-located water-surface image capture from shallow water craft, such as kayaks. The trial of the methods has shown that the approach to collection of new through-water imagery is feasible and practical.

The maps produced from the project imagery within the spatial database are the highest resolution maps of the seagrass beds known to date. The spatial database was used to produce megaquadrat based time series that were used to detect changes in submerged aquatic vegetation condition (i.e. changes from fresh bright green to darker, more mature foliage). Water surface imagery was also collected and geo-located, partly for the purpose of assisting the interpretation of the aerial imagery, but also to trial the efficacy of water surface imagery for photo monitoring. The following comments are intended to assist with forward planning.

5.1. Aerial imagery - future

There are a number of options that appear most useful for the acquisition of aerial imagery in the future, as follows:

1. Low-cost light fixed-wing aircraft with a floor port allowing the use of digital SLR cameras. For example, Stewart Wells is capable of capturing imagery over the Derwent on an opportunistic basis when conditions are favourable. The advantage of this approach is that it maximises the coverage and can be timed to take advantage of good weather and water clarity conditions. The new images could be orthorectified within the current spatial database at low cost.
2. Low-cost meso-scale imagery such as that captured from remote controlled aircraft such as the Oktocopter. An example of the imagery is provided in Figure 18. This approach could be used to directly capture target megaquadrats.
3. Satellite imagery as it becomes opportunistically available, though occasional purchases of carefully selected images may be worthwhile at times.



Figure 18 Example of the high-resolution, but limited coverage Oktocopter image mosaic showing patchy seagrass. Clarke's Beach, North West Bay, 31 December 2010. Image is approximately 250 m across.

5.2. Aerial imagery - past

Given the feasibility of using spatially imagery for mapping and monitoring submerged aquatic vegetation in the upper Derwent estuary, but also given the limited time series that was available for this project, it is worth considering making more use of the aerial photography archive. The archive holds imagery back to the mid-1940s through to the present day. An (incomplete) search of the aerial photos of the upper Derwent estuary for the 1940s, 1980s, 1990s and 2000s shows that there are around 700 images available (see listing in Appendix 3). This suggests that there are about a 1,000 images potentially available.

A rapid low-cost assessment method was developed by Mount and Otera (2011) for assessing such large number of images. It is almost certain that there will be a large number of useful historic aerial photos that will be able to assist with determining the rate and extent of changes in the seagrasses banks of the upper estuary.

5.3. Photo point monitoring

The photo monitoring procedures need to be tested and a simple photo library system established that supports analysis of the seagrass. Sites need to be identified and training of suitable image collectors conducted.

References

- Ball, D., G. D. Parry, S. Heislors, S. Blake and G. F. Werner (2006). Analysis of Victorian Seagrass Health at a Multi-regional Level Progress Report 1. Queenscliffe, Victoria, Department of Primary Industries: 54.
- Ball, D. and S. Blake (2007). Shallow Habitat Mapping in Victorian Marine National Parks and Sanctuaries. Volume 2: Eastern Victoria. Parks Victoria Technical Series. Number 37. Melbourne, Parks Victoria: 166.
- Brock, M. A. (1983). "Reproductive allocation in annual and perennial species of the submerged aquatic halophyte *Ruppia*." *Journal of Ecology* 71(3): 811-818.
- Derwent Estuary Program, 2009: Derwent Estuary Program *Environmental Management Plan*, Hobart.
- Ierodiconou, D. A. and L. J. B. Laurenson (2002). "Estimates of *Heterozostera tasmanica*, *Zostera muelleri* and *Ruppia megacarpa* distribution and biomass in the Hopkins Estuary, western Victoria, by GIS." *Australian Journal of Botany* 50(2): 215-228.
- Kuo, J. (2005). "Revision of genus *Heterozostera* (*Zosteraceae*). " *Aquatic Botany* 81: 97-140.
- Lawler, M. (2009). Video assessment of seagrass beds in the Derwent River estuary. Hobart, Tasmania, Report to the Derwent Estuary Program by the Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.
- Lucieer, V., M. Lawler, M. Morffew and A. Pender (2007). Estuarine Habitat Mapping in the Derwent- 2007 A Resurvey of Marine Habitats SeaMap Tasmania, TAFI, UTAS Final Report to the Derwent Estuary Program.
- MacDonald, M., 1995: *The Derwent Delta Marshes: Vegetation-environment relations and succession*, Honours Thesis, School of Geography and Environmental Studies, University of Tasmania, Hobart.
- Mount, R. and K. Otera (2011). The status of seagrass extent in North West Bay, Report to Kingborough Council by the Blue Wren Group, School of Geography and Environmental Studies, UTAS.
- Mount, R. E. (2007). "Rapid monitoring of extent and condition of seagrass habitats with aerial photography "mega-quadrats". *Journal of Spatial Science* 52(1): 105-119.
- Prahalad, N. V., M. J. Lacey and R. E. Mount (2009). The Future of the Derwent Estuary Saltmarshes and Tidal Freshwater Wetlands in Response to Sea Level Rise. Technical report for the Derwent Estuary Program and NRM South by the Blue Wren Group, School of Geography and Environmental Studies, University of Tasmania, Hobart, Tasmania.
- Roberts, S., G. Beattie, J. Beardall and A. Quigg (2001). Primary production, phytoplankton nutrient status and bacterial production in the Derwent River, Tasmania: Derwent River ERA, Task 7. Melbourne, A report prepared for Norske Skog Paper Mills (Australia) Ltd by the Department of Biological Sciences, Monash University.

Appendix 1. SAV Remote Sensing Project Plan

Project Aims:

1. **This project is designed to collect spatially referenced remote sensing imagery to support the environmental surveillance, inventory and monitoring of submerged aquatic vegetation (SAV), in particular, targeting seagrass in the upper and mid Derwent estuary.**
2. The imagery will be used by the Consultant to produce inventory and monitoring information products including, where the imagery permits changes in location of deep edges, seagrass density (percent cover) and patchiness (spatial metrics).
3. If resources allow the following additional assessments will be undertaken: ii) microphytobenthos (MPB) in the upper estuary, iii) MPB throughout sandflats within greater Ralphs Bay, iv) seagrass at South Arm (notably Halfmoon Bay), and v) *Macrocystis* (giant kelp) along the eastern Tinderbox Peninsula and Iron Pot areas.

Objectives

In particular,

1. The project will provide digital still images that are tied to geographical location.
2. The image capture flights will occur in each of the seasons occurring within the term of the agreement, if environmental conditions (i.e. cloud and water clarity) permit.
3. High resolution (0.5-2 m ground resolution pixels) digital still images will be acquired over the target locations designated by the DEP in agreement with the Consultant.
4. The imagery will be used by the Consultant to produce inventory and monitoring information products including, where the imagery permits, changes in location of deep edges, seagrass density (percent cover) and patchiness (spatial metrics).

Stages

1. It is proposed that the project consists of two stages, which will both be developed in conjunction with the DEP.
2. Stage One (to commence by 13 April 2009) consists of flight planning and implementation with the goal of capturing high resolution georeferenced digital still images to meet the project requirements. The target locations are to be decided in consultation with the DEP, and initially focus on i) seagrass and ii) MPB (pending ROCU access to an infra-red camera) in the upper and mid estuary. If resources allow the following additional assessments will be undertaken in subsequent steps within Stage One: iii) MPB throughout sandflats within greater Ralphs Bay, iv) seagrass at South Arm (notably Halfmoon Bay), and v) *Macrocystis* (giant kelp) along the eastern Tinderbox Peninsula and Iron Pot areas.
3. Stage Two will deliver geolocated high resolution georeferenced digital still images of the target locations in a form ready to be used for DEP purposes. The information products will be generated via image processing including digitising and image classification according to the methods described in Mount, 2006 and making use of the data supplied by the SEAMAP Tasmania Program, TAFI.
4. The results will be provided to the DEP after each flight so that the approach can be adapted to best suit the DEP's requirements. A final report will be produced summarising and interpreting the results.

Deliverables

1. **Seagrass Monitoring Work Plan.** This is a plan showing the designated target sites, and all other details of the data collection operation including flying heights, ground coverage, ground resolution units, ground control locations, specifications of weather and water conditions during the flights, and sensor instrumentation.
2. **Remote sensing products.** The original and geolocated digital aerial imagery captured during the flights.
3. **Derived spatial information products.** These are inventory and monitoring digital information products including, where the imagery permits, changes in location of deep edges, seagrass density (percent cover) and patchiness (spatial metrics).
4. **Final Project Report.** A final report summarising and interpreting the project results.

Appendix 2. SAV RS Monitoring Flight Plan

UTAS-DEP SAV Monitoring Work Plan

Richard Mount, UTAS

Project Aims:

1. **This project is designed to collect spatially referenced remote sensing imagery to support the environmental surveillance, inventory and monitoring of submerged aquatic vegetation (SAV), in particular, targeting seagrass in the upper and mid Derwent estuary.**
2. The imagery will be used by the Consultant to produce inventory and monitoring information products including, where the imagery permits changes in location of deep edges, seagrass density (percent cover) and patchiness (spatial metrics).

Image Capture Strategies:

1. The image capture flights will occur in each of the seasons occurring within the term of the agreement, if environmental conditions (i.e. cloud and water clarity) permit.
2. When water clarity is limited and, therefore, the deep edge data is not available the imagery will target the shallow flats and banks with a view to obtaining patchiness
3. High resolution (0.5-2 m ground resolution pixels) digital still images will be acquired over the target locations designated by the DEP in agreement with the Consultant.

Light Plane Flight Plan

- a. Crew
 - Plane – Par Avion Cessna 206
 - Pilot – Greg Wells, Par Avion
 - Navigator – Mark Morffew or Darren Turner or Samya Jabbour, UTAS
 - Camera Operators – Stewart Wells and Richard Mount
- b. Locations
 - Primarily along the large SAV beds around Bridgewater-Grantton-Austins Ferry
 - Secondly, at other locations, as time and resources permit
- c. Camera options
 - Stewart Wells digital camera, Canon EOS 5D (RGB)
 - Richard Mount digital cameras, Canon G10 (RGB and Near Infrared, NIR)
- d. Ground Pixel Size
 - Flying Height ~1,524 m (5,000') asl => ~0.36 m
 - Flying Height ~3,048 m (10,000') asl => ~0.7 m
- e. Image Dimensions
 - Flying Height ~1,524 m (5,000') asl => x = 1,559 m; y = 1,041 m
 - Flying Height ~3,048 m (10,000') asl => x = 3,118 m; y = 2,081 m
- f. Flight Conditions
 - Low wind (below 5 knots)
 - Sun angle between 25 and 35 degrees
 - Preferably low tide

Project Name =	DEP_0409	
Coordinate System =	MGA94	
Datum =	GDA94	
Zone =	55	
Camera Type =	Digital	
Camera Brand =	Canon EOS 5D	
Lens Type =	NORMAL	
Focal Length (f) =	35	mm
Filter =	polarising	
Film =	na	
Negative/CCD Size X (long side) =	35.8	mm
Negative/CCD Size Y (short side) =	23.9	mm
Run 1:		units
Photo Scale =	43,543	ratio
Approx. Flying Height =	1,524.0	m
=	5,000.0	ft.
Photo (Frame) Length (X) =	1,559	m
ground distance per 1° FOV		
Forward Overlap (Endlap) =	60.0	%
=	935	m
Forward Advance =	40	%
Photo Centres (Base) =	624	m
Photo (Frame) Width (Y) =	1,041	m
Sidelap =	30	%
=	312.3	m
Approx. Time tween Exposures =	14.9	secs
@ plane ground speed =	150	km/hr
Total Model Length =	8,000	m
Total Coverage Length =	744	m
No. of Photos =	13.3	actually 14
Image Size (X)	4,368	pixels
Image Size (Y)	2,912	pixels
pixel size (image)(X)	8.20	microns
pixel size (image)(Y)	8.21	microns
pixel size (ground)(X)	0.357	m
pixel size (ground)(Y)	0.357	m

Project Name =	DEP_0409	
Coordinate System =	MGA94	
Datum =	GDA94	
Zone =	55	
Camera Type =	Digital	
Camera Brand =	Canon EOS 5D	
Lens Type =	NORMAL	
Focal Length (f) =	35	mm
Filter =	polarising	
Film =	na	
Negative/CCD Size X (long side)		
=	35.8	mm
Negative/CCD Size Y (short side)		
=	23.9	mm
Run 2:		units
Photo Scale =	87,086	ratio
Approx. Flying Height =	3,048.0	m
=	10,000.0	ft.
Photo (Frame) Length (X) =	3,118	m
ground distance per 1° FOV		
Forward Overlap (Endlap) =	60.0	%
=	1,871	m
Forward Advance =	40	%
Photo Centres (Base) =	1,247	m
Photo (Frame) Width (Y) =	2,081	m
Sidelap =	30	%
=	624.3	m
Approx. Time tween Exposures =	29.9	secs
@ plane ground speed =	150	km/hr
Total Model Length =	8,000	m
Total Coverage Length =	744	m
No. of Photos =	6.9	actually 7
Image Size (X)	4,368	pixels
Image Size (Y)	2,912	pixels
pixel size (image)(X)	8.20	microns
pixel size (image)(Y)	8.21	microns
pixel size (ground)(X)	0.714	m
pixel size (ground)(Y)	0.715	m

Appendix 3. Listing of archival aerial photography over the upper Derwent estuary

Please note that there are over 700 photo listed here, but this list does not include photos from 50's, early 60's and 70's

T_PROJ_NO	AP_TITLE	FLY_DATE	AP_SCALE	AP_HEIGHT	FILM_NO	RUN_NO	NEG_NO	AP_LENS
	HOBART	02-May-46	7920	5650	16	7	14225	
	HOBART	02-May-46	7920	5650	16	7	14226	
	HOBART	02-May-46	7920	5650	16	7	14227	
	HOBART	02-May-46	7920	5650	16	7	14228	
	HOBART	02-May-46	7920	5650	16	7	14229	
	HOBART	02-May-46	7920	5650	16	7	14230	
	HOBART	20-Apr-46	7920	5650	18	11	13123	
	HOBART	20-Apr-46	7920	5650	18	11	13124	
	HOBART	20-Apr-46	7920	5650	18	11	13125	
	HOBART	20-Apr-46	7920	5650	18	11	13126	
	HOBART	20-Apr-46	7920	5650	18	11	13127	
	HOBART	20-Apr-46	7920	5650	18	11	13128	
	HOBART	20-Apr-46	7920	5650	18	11	13129	
	HOBART	20-Apr-46	7920	5650	18	11	13130	
	HOBART	04-Mar-46	15840	12000	29	1	9730	
	HOBART	04-Mar-46	15840	12000	29	1	9731	
	HOBART	04-Mar-46	15840	12000	29	1	9732	
	HOBART	04-Mar-46	15840	12000	29	1	9733	
	HOBART	04-Mar-46	15840	12000	29	1	9734	
	HOBART	04-Mar-46	15840	12000	29	1	9735	
	HOBART	04-Mar-46	15840	12000	29	1	9736	
	HOBART	04-Mar-46	15840	12000	29	1	9737	
	HOBART	04-Mar-46	15840	12000	29	1	9738	
	HOBART	04-Mar-46	15840	12000	29	1	9739	
	HOBART	04-Mar-46	15840	12000	29	1	9740	
	HOBART	04-Mar-46	15840	12000	29	1	9741	
	HOBART	04-Mar-46	15840	12000	29	1	9742	
	HOBART	04-Mar-46	15840	12000	29	1	9743	
	HOBART	04-Mar-46	15840	12000	29	1	9744	
	HOBART	04-Mar-46	15840	12000	29	1	9745	
	HOBART	04-Mar-46	15840	12000	29	1	9746	
	HOBART	04-Mar-46	15840	12000	29	1	9747	
	HOBART	04-Mar-46	15840	12000	29	1	9748	
	HOBART	04-Mar-46	15840	12000	29	1	9749	
	HOBART	04-Mar-46	15840	12000	29	1	9750	
	HOBART	04-Mar-46	15840	12000	29	2	9800	
	HOBART	04-Mar-46	15840	12000	29	2	9801	
	HOBART	04-Mar-46	15840	12000	29	2	9802	
	HOBART	04-Mar-46	15840	12000	29	2	9803	
	HOBART	04-Mar-46	15840	12000	29	2	9804	
	HOBART	04-Mar-46	15840	12000	29	2	9805	
	BRIGHTON	17-Feb-46	18180	12500	43	10	18447	

	BRIGHTON	17-Feb-46	18180	12500	43	10	18448
	BRIGHTON	17-Feb-46	18180	12500	43	10	18449
	BRIGHTON	17-Feb-46	18180	12500	43	10	18450
	BRIGHTON	17-Feb-46	18180	12500	43	10	18451
	BRIGHTON	17-Feb-46	18180	12500	43	10	18452
	BRIGHTON	17-Feb-46	18180	12500	43	10	18453
	BRIGHTON	17-Feb-46	18180	12500	43	10	18454
	BRIGHTON	17-Feb-46	18180	12500	43	10	18455
	BRIGHTON	17-Feb-46	18180	12500	43	10	18456
	BRIGHTON	17-Feb-46	18180	12500	43	10	18457
	BRIGHTON	17-Feb-46	18180	12500	43	10	18458
	BRIGHTON	17-Feb-46	18180	12500	43	10	18459
	BRIGHTON	17-Feb-46	18180	12500	43	10	18460
	BRIGHTON	17-Feb-46	18180	12500	43	10	18461
	BRIGHTON	17-Feb-46	18180	12500	43	10	18462
	BRIGHTON	17-Feb-46	18180	12500	43	10	18463
	BRIGHTON	17-Feb-46	18180	12500	43	10	18464
	BRIGHTON	17-Feb-46	18180	12500	43	10	18465
	BRIGHTON	17-Feb-46	18180	12500	43	10	18466
	BRIGHTON	17-Feb-46	18180	12500	43	10	18467
	BRIGHTON	17-Feb-46	18180	12500	43	10	18468
	BRIGHTON	17-Feb-46	18180	12500	43	10	18469
	BRIGHTON	17-Feb-46	18180	12500	43	10	18470
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	7	15
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	7	16
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	7	17
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	7	18
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	7	19
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	7	20
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	7	21
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	6	97
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	6	98
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	6	99
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	5	148
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	5	149
P1519	Derwent - D'Entrecasteaux	02-Mar-65	31680	13000	453	5	150
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	455	2	35
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	455	2	36
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	455	2	37
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	455	2	38
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	456	4	130
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	456	4	131
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	456	4	132
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	456	4	133
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	456	3	178
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	456	3	179
P1519	Derwent - D'Entrecasteaux	21-Jan-66	31680	13000	456	3	180
P1674	FIRE ASSESSMENT	18-Feb-67	15840	12000	488	24	28

P1674	FIRE ASSESSMENT	18-Feb-67	15840	12000	488	24	29	
P1674	FIRE ASSESSMENT	18-Feb-67	15840	12000	488	24	30	
P1674	FIRE ASSESSMENT	18-Feb-67	15840	12000	488	25	33	
P1674	FIRE ASSESSMENT	18-Feb-67	15840	12000	488	25	34	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	94	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	95	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	96	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	97	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	98	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	99	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	100	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	101	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	102	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	3	103	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	2	112	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	2	113	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	2	114	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	509	2	115	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	1	31	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	1	32	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	1	33	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	134	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	135	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	136	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	137	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	138	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	139	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	140	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	141	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	142	
P0012	HOBART REVISION (1969)	23-Jan-69	14400	12500	510	4	143	
P0012	HOBART REVISION (1969)	24-Jan-69	14400	12500	510	5	202	
P0012	HOBART REVISION (1969)	24-Jan-69	14400	12500	510	5	203	
P0012	HOBART REVISION (1969)	24-Jan-69	14400	12500	510	5	204	
P0012	HOBART REVISION (1969)	24-Jan-69	14400	12500	510	5	205	
P0012	HOBART REVISION (1969)	24-Jan-69	14400	12500	510	5	206	
M55NN	NEW NORFOLK	7-JAN-84	5000	5100	973	1	209	305
M55NN	NEW NORFOLK	7-JAN-84	5000	5100	975	2	29	305
M55NN	NEW NORFOLK	7-JAN-84	5000	5100	975	2	30	305
M385	RICHMOND - GREEN PONDS	13-JAN-84	15000	15000	976	93	219	305
M385	RICHMOND - GREEN PONDS	13-JAN-84	15000	15000	976	93	220	305
M385	RICHMOND - GREEN PONDS	13-JAN-84	15000	15000	976	93	221	305
M385	RICHMOND - GREEN PONDS	13-JAN-84	15000	15000	976	93	222	305
M385	RICHMOND - GREEN PONDS	13-JAN-84	15000	15000	976	93	223	305
M385	RICHMOND - GREEN PONDS	13-JAN-84	15000	15000	977	92	203	305
M385	RICHMOND - GREEN PONDS	13-JAN-84	15000	15000	977	92	204	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	2	11	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	2	12	305

M379	HOBART CENSUS	5-FEB-84	20000	21000	983	3	19	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	3	20	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	3	21	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	3	22	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	3	23	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	3	24	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	4	54	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	4	55	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	4	56	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	4	57	305
M379	HOBART CENSUS	5-FEB-84	20000	21000	983	4	61	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	222	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	223	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	224	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	225	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	226	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	227	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	228	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	229	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	230	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	231	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	232	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	233	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	234	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	235	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	236	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	237	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	238	305
M55HO	HOBART AREA	18-FEB-84	5000	5100	986	10N	239	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	6	158	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	6	159	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	6	160	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	6	161	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	6	162	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	6	163	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	6	164	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	165	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	166	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	167	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	168	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	169	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	170	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	171	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	172	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	7	173	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	8	221	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	8	222	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	8	223	305

M55HO	HOBART AREA	11-MAR-84	5000	5100	995	8	224	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	8	225	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	8	226	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	8	227	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	8	228	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	230	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	231	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	232	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	233	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	234	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	235	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	236	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	237	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	238	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	239	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	240	305
M55HO	HOBART AREA	11-MAR-84	5000	5100	995	9	241	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	61	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	62	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	63	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	64	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	65	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	66	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	67	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	68	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	69	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	70	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	71	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	72	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	73	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	74	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	75	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	76	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	77	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	11	78	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	158	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	159	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	160	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	161	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	162	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	163	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	164	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	165	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	166	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	167	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	168	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	169	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	170	305

M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	171	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	172	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	173	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	174	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	175	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	12	176	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	177	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	178	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	179	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	180	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	181	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	182	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	183	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	184	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	185	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	186	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	187	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	188	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	189	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	190	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	191	305
M55HO	HOBART AREA	2-APR-84	5000	5100	998	13A	192	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	36	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	37	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	38	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	39	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	40	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	41	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	42	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	43	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	14N	44	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	15	55	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	15	56	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	15	57	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	15	58	305
M55HO	HOBART AREA	2-APR-84	5000	5100	999	15	59	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	43	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	44	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	45	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	46	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	47	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	48	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	49	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	50	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	51	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	52	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	53	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	54	305

M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	55	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	56	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	57	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	58	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	59	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	60	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	61	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	11	62	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	63	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	64	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	65	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	66	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	67	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	68	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	69	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	70	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	71	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	72	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	73	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	74	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	75	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	76	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	77	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	78	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	79	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	80	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	81	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	10N	82	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9S	143	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9S	144	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	145	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	146	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	147	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	148	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	149	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	150	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	151	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	152	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	153	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	154	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	155	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	156	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	157	305
M542	HOBART AREA	4-NOV-85	5000	5100	1043	9N	158	305
M548	SOUTH EAST	13-NOV-85	42000	22500	1044	35	70	153
M548	SOUTH EAST	13-NOV-85	42000	22500	1044	35	71	153
M548	SOUTH EAST	13-NOV-85	42000	22500	1044	35	72	153
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	4	109	305

M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	4	110	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	4	111	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	4	112	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	4	113	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	3N	128	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	3N	129	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	3N	130	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	3N	131	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	3N	132	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	3N	133	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	3N	134	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	2	174	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	2	175	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	2	176	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	2	177	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	2	178	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	2	179	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	2	180	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	1	192	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	1	193	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	1	194	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	1	195	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	1	196	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	1	197	305
M628	HOBART ATLAS REVISION	26-FEB-86	12500	12700	1059	1	198	305
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	7	133	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	7	134	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	7	135	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	7	136	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	7	137	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	7	138	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	7	139	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	7	140	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	141	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	142	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	143	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	144	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	145	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	146	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	147	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	148	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	149	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	150	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	151	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	152	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	153	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	154	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	155	153

M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	156	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	157	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	6	158	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	187	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	188	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	189	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	190	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	191	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	192	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	193	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	194	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	195	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	196	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	197	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	198	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	199	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	200	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	201	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	202	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	203	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	204	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	205	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	206	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	207	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	208	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	209	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	210	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	8	211	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	212	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	213	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	214	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	215	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	216	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	217	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	218	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	219	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	220	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	221	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	222	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	223	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	224	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	225	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	226	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1082	9	227	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	13	1	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	13	2	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	13	3	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	13	4	153

M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	13	5	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	13	6	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	13	7	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	13	8	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	11	23	153
M688	BOWEN BRIDGE DYSART	02-FEB-87	8000	4530	1083	4	45	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	1	167	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	1	168	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	1	169	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	1	170	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	1	171	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	1	172	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	1	173	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	178	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	179	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	180	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	181	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	182	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	183	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	184	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	185	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	2	186	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	3N	195	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	3N	196	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	3N	197	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	3N	198	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	3N	199	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	3N	200	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	3N	201	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1098	3N	202	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1105	4	8	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1105	4	9	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1105	4	10	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1105	4	11	153
M628	HOBART AREA 1988	04-FEB-88	12500	6450	1105	4	12	153
M797	MEEHAN RANGE	23-NOV-88	23000	12000	1116	1	6	153
M797	MEEHAN RANGE	23-NOV-88	23000	12000	1116	1	7	153
M797	MEEHAN RANGE	23-NOV-88	23000	12000	1116	1	8	153
M797	MEEHAN RANGE	23-NOV-88	23000	12000	1116	1	9	153
M797	MEEHAN RANGE	23-NOV-88	23000	12000	1116	1	10	153
M797	MEEHAN RANGE	23-NOV-88	23000	12000	1116	1	11	153
M797	MEEHAN RANGE	23-NOV-88	23000	12000	1116	1	12	153
M797	MEEHAN RANGE	23-NOV-88	23000	12000	1116	2	17	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	1N	111	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	1N	112	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	1N	113	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	1N	114	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	1N	115	153

M802	HOBART AREA	22-DEC-88	12500	6500	1120	1N	116	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	1N	117	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	1N	118	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	2	160	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	2	161	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	2	162	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	2	163	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	2	164	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	2	165	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	2	166	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	3	179	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	3	180	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	3	181	153
M802	HOBART AREA	22-DEC-88	12500	6500	1120	3	182	153
M55NN	NEW NORFOLK	1-MAR-89	12500	6300	1137	1	48	153
M864	HOBART AREA	07-DEC-89	12500	12800	1142	1	106	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	1	107	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	1	108	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	1	109	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	1	110	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	1	111	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	1	112	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	1	113	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	2	124	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	2	125	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	2	126	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	2	127	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	2	128	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	2	129	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	2	130	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	3	187	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	3	188	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	3	189	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	3	190	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	4	202	305
M864	HOBART AREA	07-DEC-89	12500	12800	1142	4	203	305
M85CM	CLAREMONT GOLF COURSE	17-DEC-89	7000	7000	1144	0	132	305
M85CM	CLAREMONT GOLF COURSE	17-DEC-89	7000	7000	1144	0	133	305
M55CV	COLLINSVALE	7-DEC-89	12500	13250	1145	4	123	305
M55CV	COLLINSVALE	7-DEC-89	12500	13250	1145	4	124	305
M55CV	COLLINSVALE	7-DEC-89	12500	13250	1145	4	125	305
M875	HUON - KINGBOROUGH OPM	22-JAN-90	24000	13000	1147	10	228	153
M880	PROSSER NUGENT	25-FEB-90	42000	22500	1154	35	38	153
M897	DERWENT WATER SUPPLY	16-MAR-90	7500	4000	1154	2	172	153
M897	DERWENT WATER SUPPLY	16-MAR-90	7500	4000	1154	3	184	153
M897	DERWENT WATER SUPPLY	16-MAR-90	7500	4400	1154	1	196	153
M897	DERWENT WATER SUPPLY	16-MAR-90	7500	4400	1154	1	197	153
M922	NEW NORFOLK -	2-JAN-91	26000	14000	1162	3	84	153

COLLINSVALE								
M922	NEW NORFOLK - COLLINSVALE	2-JAN-91	26000	14000	1162	3	85	153
M922	NEW NORFOLK - COLLINSVALE	2-JAN-91	26000	14000	1162	3	86	153
M922	NEW NORFOLK - COLLINSVALE	2-JAN-91	26000	14000	1162	3	87	153
M922	NEW NORFOLK - COLLINSVALE	2-JAN-91	26000	14000	1162	3	88	153
M911CL	CLAREMONT	2-FEB-91	6000	6000	1166	0	52	305
M985	HOBART	16-FEB-92	12500	13500	1183	1	166	305
M985	HOBART	16-FEB-92	12500	13500	1183	1	167	305
M985	HOBART	16-FEB-92	12500	13500	1183	1	168	305
M985	HOBART	16-FEB-92	12500	13500	1183	1	169	305
M985	HOBART	16-FEB-92	12500	13500	1183	1	170	305
M985	HOBART	16-FEB-92	12500	13500	1183	1	171	305
M985	HOBART	16-FEB-92	12500	12800	1183	2	177	305
M985	HOBART	16-FEB-92	12500	12800	1183	2	178	305
M985	HOBART	16-FEB-92	12500	12800	1183	2	179	305
M985	HOBART	16-FEB-92	12500	12800	1183	2	180	305
M985	HOBART	16-FEB-92	12500	12800	1183	2	181	305
M985	HOBART	16-FEB-92	12500	12800	1183	2	182	305
M985	HOBART	16-FEB-92	12500	12800	1183	2	183	305
M985	HOBART	16-FEB-92	12500	12800	1183	2	184	305
M985	HOBART	16-2-92	12500	12800	1184	3N	14	305
M985	HOBART	16-2-92	12500	12800	1184	3N	15	305
M985	HOBART	16-2-92	12500	12800	1184	3N	16	305
M985	HOBART	16-2-92	12500	12800	1184	3N	17	305
M985	HOBART	16-2-92	12500	12800	1184	3N	18	305
M985	HOBART	16-2-92	12500	12800	1184	3N	19	305
M985	HOBART	16-2-92	12500	12800	1184	4	29	305
M985	HOBART	16-2-92	12500	12800	1184	4	30	305
M985	HOBART	16-2-92	12500	12800	1184	4	31	305
M985	HOBART	16-2-92	12500	12800	1184	4	32	305
M985	HOBART	16-2-92	12500	12800	1184	4	33	305
M985	HOBART	16-2-92	12500	12800	1184	5	91	305
M985	HOBART	16-2-92	12500	12800	1184	5	92	305
M990NN	NEW NORFOLK	19-FEB-92	12500	12550	1186	2	23	305
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	101	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	102	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	103	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	104	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	105	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	106	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	107	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	108	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	109	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	110	153
A046	Gagebrook OPM 93-94	16-NOV-93	24000	12000	1203	1	111	153
M797	Meehan Range OPM 93-94	12-FEB-94	24000	12500	1217	1	132	153
M797	Meehan Range OPM 93-94	12-FEB-94	24000	12500	1217	1	133	153

M797	Meehan Range OPM 93-94	12-FEB-94	24000	12500	1217	1	134	153
M797	Meehan Range OPM 93-94	12-FEB-94	24000	12500	1217	1	135	153
M797	Meehan Range OPM 93-94	12-FEB-94	24000	12500	1217	1	136	153
M797	Meehan Range OPM 93-94	12-FEB-94	24000	12500	1217	1	137	153
M797	Meehan Range OPM 93-94	12-FEB-94	24000	12500	1217	1	138	153
M55NN	NEW NORFOLK	20-2-95	12500	12600	1231	2	200	305
A083	HOBART AREA	3-3-95	12500	12800	1233	1	121	305
A083	HOBART AREA	3-3-95	12500	12800	1233	1	122	305
A083	HOBART AREA	3-3-95	12500	12800	1233	1	123	305
A083	HOBART AREA	3-3-95	12500	12800	1233	1	124	305
A083	HOBART AREA	3-3-95	12500	12800	1233	1	125	305
A083	HOBART AREA	3-3-95	12500	12800	1233	1	126	305
A083	HOBART AREA	3-3-95	12500	12800	1233	1	127	305
A083	HOBART AREA	3-3-95	12500	12800	1233	1	128	305
A083	HOBART AREA	3-3-95	12500	12800	1233	2S	195	305
A083	HOBART AREA	3-3-95	12500	12800	1233	2S	196	305
A083	HOBART AREA	3-3-95	12500	12800	1234	2N	7	305
A083	HOBART AREA	3-3-95	12500	12800	1234	2N	8	305
A083	HOBART AREA	3-3-95	12500	12800	1234	2N	9	305
A083	HOBART AREA	3-3-95	12500	12800	1234	2N	10	305
A083	HOBART AREA	3-3-95	12500	12800	1234	2N	11	305
A083	HOBART AREA	3-3-95	12500	12800	1234	2N	12	305
A083	HOBART AREA	3-3-95	12500	12800	1234	3	19	305
A083	HOBART AREA	3-3-95	12500	12800	1234	3	20	305
A083	HOBART AREA	3-3-95	12500	12800	1234	3	21	305
A083	HOBART AREA	3-3-95	12500	12800	1234	3	22	305
A083	HOBART AREA	11-3-95	12500	12800	1234	4	81	305
A106HD	HUON - DERWENT	19-JAN-97	24000	12500	1260	10N	194	153
A106HD	HUON - DERWENT	19-JAN-97	24000	12500	1260	10N	195	153
A106HD	HUON - DERWENT	19-JAN-97	24000	12500	1260	10N	196	153
A106HD	HUON - DERWENT	19-JAN-97	24000	13000	1260	9N	216	153
A106HD	HUON - DERWENT	19-JAN-97	24000	13000	1260	9N	217	153
A106HD	HUON - DERWENT	19-JAN-97	24000	13000	1260	9N	218	153
A106HD	HUON - DERWENT	19-JAN-97	24000	13000	1260	9N	219	153
A106HD	HUON - DERWENT	19-JAN-97	24000	13000	1260	8N	222	153
A106HD	HUON - DERWENT	19-JAN-97	24000	13000	1260	8N	223	153
A106HD	HUON - DERWENT	19-JAN-97	24000	13000	1260	8N	224	153
A110	SOUTHERN REVISION	13-JAN-97	42000	22500	1262	35	118	153
A110	SOUTHERN REVISION	13-JAN-97	42000	22500	1262	35	119	153
A110	SOUTHERN REVISION	13-JAN-97	42000	22500	1262	35	120	153
M990MB	MILVALE-BOYER RD	15-FEB-97	5000	5000	1269	0	147	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1269	4	177	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1269	4	178	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	3	32	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	3	33	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	3	34	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	3	35	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	2	53	305

A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	2	54	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	2	55	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	2	56	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	2	57	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	2	58	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	2	59	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	1	141	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	1	142	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	1	143	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	1	144	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	1	145	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	1	146	305
A083	HOBART ATLAS REVISION	15-FEB-97	12500	12800	1271	1	147	305
A106H	HUON - DERWENT ROAD UPDATE	09-JAN-98	24000	14000	1280	7N	103	153
A106H	HUON - DERWENT ROAD UPDATE	09-JAN-98	24000	14000	1280	7N	104	153
A106H	HUON - DERWENT ROAD UPDATE	12-JAN-98	24000	14000	1285	9CN	93	153
A106H	HUON - DERWENT ROAD UPDATE	12-JAN-98	24000	14000	1285	9CN	94	153
A106H	HUON - DERWENT ROAD UPDATE	12-JAN-98	24000	14000	1285	9CN	95	153
A131	DERWENT REVISION	14-DEC-99	42000	22100	1320	35	155	153
A131	DERWENT REVISION	14-DEC-99	42000	22100	1320	35	156	153
A131	DERWENT REVISION	14-DEC-99	42000	22100	1320	35	157	153
A131	DERWENT REVISION	14-DEC-99	42000	22100	1320	35	158	153
A135HD	HUON - DERWENT : URBAN OPM	03-JAN-01	24000	13000	1341	8N	63	153
A135HD	HUON - DERWENT : URBAN OPM	03-JAN-01	24000	13000	1341	8N	64	153
A135HD	HUON - DERWENT : URBAN OPM	03-JAN-01	24000	13000	1341	8N	65	153
A135HD	HUON - DERWENT : URBAN OPM	03-JAN-01	24000	13000	1341	9N	67	153
A135HD	HUON - DERWENT : URBAN OPM	03-JAN-01	24000	13000	1341	9N	68	153
A135HD	HUON - DERWENT : URBAN OPM	03-JAN-01	24000	13000	1341	9N	69	153
A135HD	HUON - DERWENT : URBAN OPM	21-JAN-01	24000	12600	1343	10N	208	153
A135HD	HUON - DERWENT : URBAN OPM	21-JAN-01	24000	12600	1343	10N	209	153
A135HD	HUON - DERWENT : URBAN OPM	21-JAN-01	24000	12600	1343	10N	210	153
A135HD	HUON - DERWENT : URBAN OPM	21-JAN-01	24000	14000	1343	9CN	218	153
A135HD	HUON - DERWENT : URBAN OPM	21-JAN-01	24000	14000	1343	9CN	219	153
A135HD	HUON - DERWENT : URBAN OPM	21-JAN-01	24000	14000	1343	9CN	220	153
A135HD	HUON - DERWENT : URBAN OPM	21-JAN-01	24000	14000	1344	7CN	37	153
A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	12	153
A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	13	153
A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	14	153
A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	15	153
A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	16	153

A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	17	153
A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	18	153
A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	19	153
A140HB	HOBART AREA	23-NOV-02	10000	5800	1361	1	20	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	26	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	27	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	28	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	29	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	30	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	31	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	32	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	33	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	34	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	35	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	2	36	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	70	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	71	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	72	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	73	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	74	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	75	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	76	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	77	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	3N	78	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	4N	96	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	4N	97	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	4N	98	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	4N	99	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	4N	100	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	4N	101	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	4N	102	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	5	169	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	5	170	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	5	171	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	5	172	153
A140HB	HOBART AREA	23-NOV-02	10000	5400	1361	5	173	153
A110	SOUTHERN REVISION 2002-03	02-FEB-03	42000	22500	1368	35	117	153
A110	SOUTHERN REVISION 2002-03	02-FEB-03	42000	22500	1368	35	118	153
A110	SOUTHERN REVISION 2002-03	02-FEB-03	42000	22500	1368	35	119	153
A110	SOUTHERN REVISION 2002-03	02-FEB-03	42000	22500	1368	35	120	153
A136F174	FORESTRY AREA : F174	08-FEB-03	15000	8400	1369	1	180	153
A136F173	FORESTRY AREA : F173	08-FEB-03	15000	8400	1369	1	181	153
A136F173	FORESTRY AREA : F173	08-FEB-03	15000	8400	1369	1	182	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	13000	1382	9N	118	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	13000	1382	9N	119	153
A135HD	HUON-DERWENT : URBAN	28-MAR-04	24000	13000	1382	9N	120	153

OPM								
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	13000	1382	8N	122	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	13000	1382	8N	123	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	13000	1382	8N	124	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	12600	1382	10N	134	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	12600	1382	10N	135	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	12600	1382	10N	136	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	14000	1382	9CN	147	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	14000	1382	9CN	148	153
A135HD	HUON-DERWENT : URBAN OPM	28-MAR-04	24000	14000	1382	9CN	149	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	233	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	234	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	235	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	236	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	237	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	238	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	239	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	240	153
A140HB	HOBART AREA	09-DEC-06	10000	5800	1413	1	241	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	24	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	25	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	26	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	27	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	28	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	29	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	30	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	31	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	32	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	33	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	2	34	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	49	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	50	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	51	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	52	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	53	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	54	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	55	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	56	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	3N	57	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	4N	77	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	4N	78	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	4N	79	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	4N	80	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	4N	81	153

A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	4N	82	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	4N	83	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	5	151	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	5	152	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	5	153	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	5	154	153
A140HB	HOBART AREA	09-DEC-06	10000	5400	1417	5	155	153
A110	SOUTHERN REVISION 2007	13-FEB-07	42000	22500	1422	35	21	153
A110	SOUTHERN REVISION 2007	13-FEB-07	42000	22500	1422	35	22	153
A110	SOUTHERN REVISION 2007	13-FEB-07	42000	22500	1422	35	23	153
A110	SOUTHERN REVISION 2007	13-FEB-07	42000	22500	1422	35	24	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	13000	1430	8N	136	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	13000	1430	8N	137	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	13000	1430	8N	138	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	14000	1430	7N	193	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	12600	1431	10N	175	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	12600	1431	10N	176	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	12600	1431	10N	177	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	14000	1431	9CN	197	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	14000	1431	9CN	198	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	14000	1431	9CN	199	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	13000	1431	9N	207	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	13000	1431	9N	208	153
A135HD	HUON - DERWENT: URBAN ORTHO	18-FEB-08	24000	13000	1431	9N	209	153
		08-Nov-09	42000	22600	1440			162
		08-Nov-09	42000	22600	1440			163
		08-Nov-09	42000	22600	1440			164